

DESIGNING THE DEVELOPMENT OF GAS TRANSMISSION INFRASTRUCTURE – CHARACTERISTICS, SPECIFICS AND METHODOLOGICAL FRAMEWORK

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Abstract: *This manuscript examines infrastructure projects for the development of the gas transmission network as a specific category of capital investments of key importance for energy security and sustainable economic development. The characteristics of the gas transmission infrastructure are analyzed, such as long-term planning horizon, high capital intensity, strategic importance and regulatory commitment. Special attention is paid to the specific challenges facing these projects expressed in technological complexity, cross-border dimension, environmental requirements and coordination among multiple stakeholders. At the end, the author's vision of a methodological framework for planning, assessment and management of projects in the sector, including technical and economic analysis, risk assessment and compliance with the European regulatory framework, is developed. The conclusions highlight the need for an integrated approach combining engineering, financial and legal competencies in the implementation of such strategic projects.*

Keywords: *Gas transmission network, Gas projects characteristics, European regulatory framework, Technical and economic analysis, Risk assessment.*

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1. Introduction

Gas transmission infrastructure occupies a central place in the energy security of modern economies. Investments in it are distinguished by a long-term horizon and high capital intensity. They have strategic importance and are closely linked to the regulatory environment. This significantly distinguishes them from conventional capital projects. The implementation of such projects is accompanied by a number of specific challenges. Technological complexity places high demands on engineering planning. The cross-border dimension requires coordination between various national and supranational institutions. Environmental standards and coordination with multiple stakeholders further complicate the process. This report examines these projects in their entirety.

The aim is to propose a methodological framework for their planning, assessment and management, which would integrate technical and economic analysis, risk assessment and compliance with European legislation. The successful implementation of such projects requires engineering, financial and legal competencies at the same time. The guiding idea is that only an integrated approach can ensure the effective management of strategic investments in expanding the gas transmission network.

2. Literature Review

The development of gas transmission infrastructure in modern conditions requires the application of a comprehensive project approach that integrates technical, economic, environmental and social aspects of the investment process. A number of fundamental

studies in the field of project management in the energy sector argue that the specificity of infrastructure projects in the gas sector is determined by the unique combination of a long-term investment horizon, high capital requirements and strategic importance for energy security (Al-Bdairi, Naji, & Abed, 2025).

These projects have a direct relationship to ecology and environmental protection, which is reflected in the implementation of specific ESG policies by companies in the gas production and gas transmission sectors (Mustafa & Yucel, 2024). These and other studies (Esty, 2004) conclude that infrastructure projects in the gas transmission sector have their own specific and often unique time, financial, technical, environmental (Zahariev, et al., 2023) and social dimensions, with corresponding characteristics, specific challenges and approaches to their management (see Table 1).

Table 1. Characteristics of infrastructure projects in the gas transmission sector

| Dimension | Characteristics | Specific challenges | Management approaches |
|---------------|-----------------------------------|-------------------------------|----------------------------------|
| Time | Long-term horizon (20-40 years) | Forecasting uncertainty | Scenario planning |
| Financial | High capital costs | Complex financial structuring | Innovative financial instruments |
| Technical | Complex engineering solutions | Technological risks | Integrated risk management |
| Environmental | Strict environmental requirements | Regulatory compliance | Environmental management |
| Social | Wide range of stakeholders | Social impact | Inclusive governance |

Source: Author analysis

In practice, the question to be addressed is not whether, but to what extent ESG policies and requirements influence the strategic development of the sector and new investments in expanding the gas transmission and supply network (Ramírez-Orellana, Martínez-Victoria, García-Amate, & Rojo-Ramírez, 2024). Through the prism of environmental regulations, there are a number of confirmations in the literature that corporate financial strategy is strongly influenced and should be adapted to the impacts of ESG regulations (Zahariev, et al., 2024b).

ESG regulations achieve a direct impact on the returns of public companies in the gas sector, which is defined as a risk factor with a systematic nature for the industry (Sadorsky, 2001). They are influenced not only by factors typical for the construction sector (Zahariev, Zaharieva, Shaulska, Larysa, & Oryekhov, 2026), but also by additional ones directly related to ESG regulations (Zahariev, et al., 2024a).

3. Methodology

The methodology of the study is based on the concept of the decisive importance of the prior institutional structuring on the success of investments in gas transmission infrastructure, compared with the technical characteristics and engineering implementation (Miller, Lessard, Michaud, & Floricel, 2001). The institutional framework of project management in the gas transmission sector is characterized by a complex architecture of interacting organizations and regulatory mechanisms. In practice, we support the concept of multi-layered project management, which integrates the different levels of decision-making - from strategic planning to operational implementation.

The institutional responsibilities in project management are distributed across four levels. Each of them performs specific functions and produces specific results (EIB, 2005). At the strategic level, policies are formed that determine the direction of development. Coordination is carried out through interdepartmental working groups (Herrera, Sánchez, Castañeda, & Porras, 2020). The result of this activity are the strategic documents on which the overall management framework is built (Ushenko, et al., 2023). The regulatory level is responsible for the control and supervision of implementation. It functions through established regulatory procedures and creates the permitting regimes without which no project can start (Gatti, 2007). The operational level is where projects are actually implemented. Project teams are the main coordination mechanism at this level, and their final product is the infrastructure facilities themselves (Zahariev & Prodanov, 2017). The monitoring level closes the management cycle. It evaluates the achieved results through specialized monitoring systems (Quarton & Samsatli, 2018). The output of this activity are the reports and analyses that inform subsequent management decisions.

The scientific literature in the field of infrastructure projects and especially in the gas transmission sector has demonstrated significant evolution over the last decade, reflecting the increasing complexity of the challenges facing the industry (Al-Yafei, et al., 2026). In a fundamental study from 2025, focused on the lessons of infrastructure megaprojects, a conceptual framework for analyzing the specificity of gas transmission projects is developed, emphasizing their strategic importance and long-term impact on the energy system (Lou, Afshari, Johansen, Nygaard Rasmussen, & Bohne, 2025). The authors argue that traditional approaches to project management do not sufficiently consider the unique characteristics of infrastructure projects and the need for an integrated approach to their development.

The analysis of the contemporary scientific literature reveals several dominant research directions. First, the strategic aspects of infrastructure development are considered, emphasizing the need for long-term planning and integration with energy policy (Hadi, Supomo, Achmadi, & Baihaqi, 2026). Research demonstrates that the successful implementation of gas transmission projects requires a thorough understanding of geopolitical factors and trends in the development of global energy markets (Rqiq, Beyza, Yusta, & Bolado-Lavin, 2020). In addition to economic considerations, attention is focused on the technological aspects of project implementation (Kaulbeck, 2015). The analyses reveal the growing importance of innovative technological solutions for increasing the efficiency and reliability of gas transmission infrastructure.

In methodological terms, modern research demonstrates a trend towards integrating different analytical approaches. Priority is given to a complex methodological framework combining quantitative and qualitative methods for analyzing infrastructure projects (Lewis & Mervyn, 2004). This methodology allows for a more precise assessment of project risks and more effective resource management. The most innovative approaches to project risk assessment are based on the use of artificial intelligence and machine learning. Their results demonstrate significant potential for improving the accuracy of risk assessments and optimizing management decisions.

4. Results and Discussion

The world's entry into a series of energy crises caused by military conflicts, sanctions and blockades of sea routes has led to a review of natural gas supply chains, whose conservative matrix connected the point of the deposit with the sales markets through pipeline infrastructure. The new technological solution for gas transmission via LNG tankers has led to the need for accelerated investments in gasification and regasification terminals. Due to the impossibility of natural gas being transported by sea in its gaseous state, installations for liquefaction at -162°C and subsequent transportation by tankers are being built. Thus, investments in regasification terminals are being put at the forefront of natural gas supply chains. Their financing is also developing new bond instruments, which have gained popularity as “green bonds” (Alonso-Conde & Rojo-Suárez, 2020).

The terminals themselves are industrial facilities whose main purpose is to receive liquefied natural gas, store it and convert it back into gas for the distribution network. In this way, the terminals connect maritime transport with the land-based gas transmission infrastructure and form a critical node in the global supply chain. Regasification terminals already play a significant role in the security and diversification of energy supplies. They can receive natural gas from anywhere in the world and provide flexibility by increasing or decreasing production depending on demand. This makes them a tool not only for the physical transportation of gas, but also for managing market risk (Pavlov & Kostov, 2023). From a technological point of view, investments are focused on two main types of terminals. Land-based terminals have permanent infrastructure and large storage capacity. Floating storage and regasification units (FSRU) are preferred due to their shorter commissioning times and lower initial costs compared to land-based terminals.



Figure 1. Alexandroupolis and Thrace LNG Terminals as entry point for gas delivery to SEE

Source: Gastrade, 26th National Energy Congress “Energy + Development 2022”, 22-23.11.2022

The importance of these facilities is growing in the context of energy security. Events after 2022 and the reduction of Russian supplies through the underground pipeline network have accelerated the construction of new terminals in Europe. Of particular importance for the Balkan Peninsula and South-eastern Europe is the investment in the LNG terminal at Alexandroupolis (See Figure 1).

The Alexandroupolis LNG Terminal Project is an initiative of the Greek company Gastrade, founded in 2010, with the aim of designing, building, operating and managing an infrastructure for the reception, transmission and distribution of natural gas. It is positioned as the most significant new infrastructure project for energy security and diversification in the South-Eastern European region. The project is a response to a structural vulnerability in the region. The countries of Central and South-Eastern Europe are dependent on Russian gas by about 60%, or 22–23 billion cubic meters per year by 2021. The only alternative infrastructures in operation are the TAP gas pipeline and the LNG terminals in Revithoussa (Greece) and Krk (Croatia). The Balkan and SEE markets are among the few European markets with an expected growth of about 10% in the period 2021–2030, which further justifies the need for the project.

The terminal is built on the basis of a floating storage and regasification unit (FSRU), positioned about 15 km southwest of Alexandroupolis, about 8 km from the coast. The facility has a storage capacity of 170,000 to 185,000 cubic meters of LNG and a maximum regasification rate of 650,000 Nm³/h, corresponding to about 6 billion cubic meters per year (See Figure 2). The permanent infrastructure includes a mooring system, a pipeline and a connection to the Greek National Gas Transmission Network and/or TAP. In addition, a second Thrace LNG terminal is being developed, which will operate in parallel with the main one.

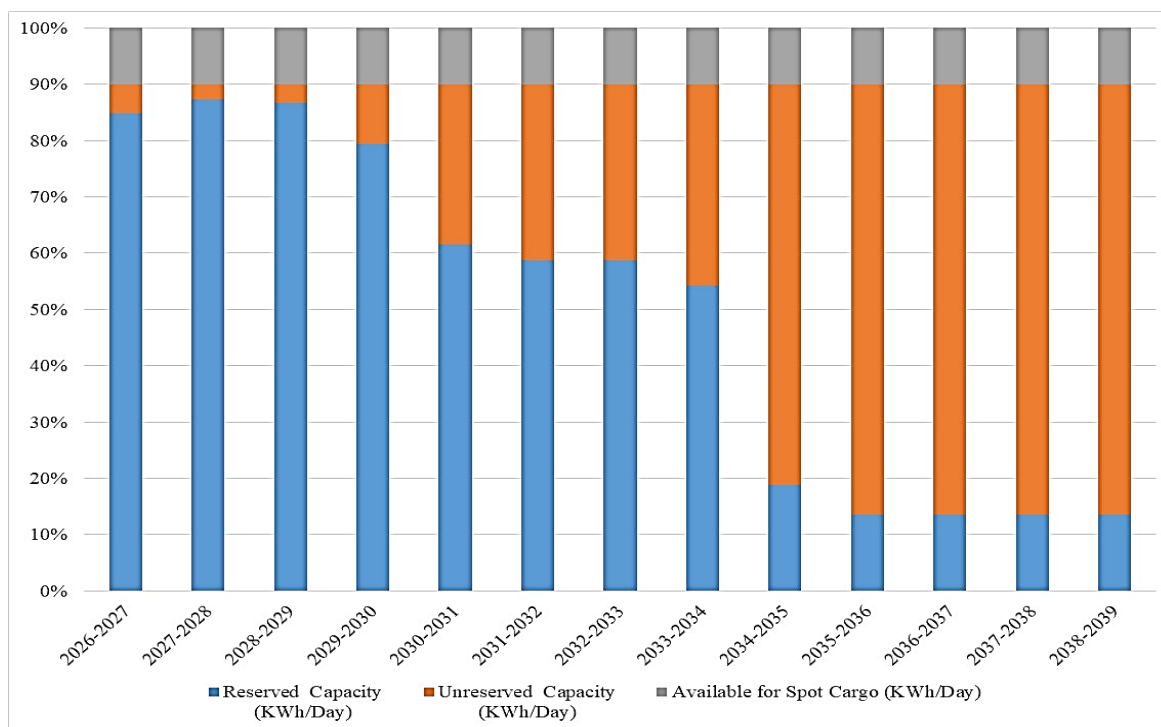


Figure 2. Capacity of Alexandroupolis LNG terminal (2026-2029)

Source: Visualization by the author based on data from Gastrade, <https://tutps.gastrade.gr/public-documents>

The estimated investment value of the project amounts to 510 million euros. The financing is structured through a combination of debt financing and grants, co-financed by Greece and the European Union. Gastrade is the operator of the facility and is structured with equal participation of five partners, each with a 20% share: Elmina Copelouzou, Gaslog Cyprus Investments (a leader in marine LNG transport), DEPA Commercial (the public gas company of Greece), Bulgartransgaz (the operator of the Bulgarian gas transmission network) and DESFA (the Greek gas transmission network operator). This balanced capital structure (Zahariev A., 2014) acts as an amplifying factor for the constant loading of the capacity of the facility. Gastrade was licensed in 2015 and the market test was conducted until 2017. After securing debt financing, construction works and laying of pipelines began. The floating platform was built at the Seatrium shipyard in Singapore and transported to the anchorage in Alexandroupoulos Bay between 26.11-17.12.2023.

The facility was officially opened on 1.10.2024 with a daily technical regasification capacity of 181.5 GWh/day, which covers the consumption of nearly 5 million households. Through the network of already built interconnections and underground gas pipelines, the facility supplies gas to consumers in 9 countries - Greece, Bulgaria, Romania, North Macedonia, Serbia, Moldova, Ukraine, Hungary and Slovakia. By 2030, the facility has a reserved capacity of 84.6%.

In light of the new crisis with the Gulf War and the blockade of the Strait of Hormuz, LNG regasification terminals are becoming much more than technical facilities (Esty, 2004). They are strategic assets that determine the degree of energy independence, supply diversification, flexibility of national gas systems and price balancing (Zahariev & Kostov, 2016). Therefore, access to LNG import terminals and markets is becoming increasingly important within the framework of regional energy strategies, especially in the EU, where the aim is to increase resilience to supply disruptions.

5. Conclusions

Empirical and theoretical research in the field provides valuable data on the practical aspects of project implementation. In the analysis of implemented projects in the European gas sector and especially the Alexandroupolis LNG terminal project, the key success factors of project failures are identified. The conclusions from these studies are of great importance for improving project practices and minimizing risks.

The review of the scientific literature demonstrates the significant progress in understanding the specifics of infrastructure projects in the gas transmission sector. At the same time, new research challenges are outlined, related to the need to adapt to changing technological and market conditions. The presented literature review reveals the wealth of scientific research in the field and emphasizes the need for an integrated approach to the analysis and management of infrastructure projects in the gas transmission sector.

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